Create a 21st Century Electric System

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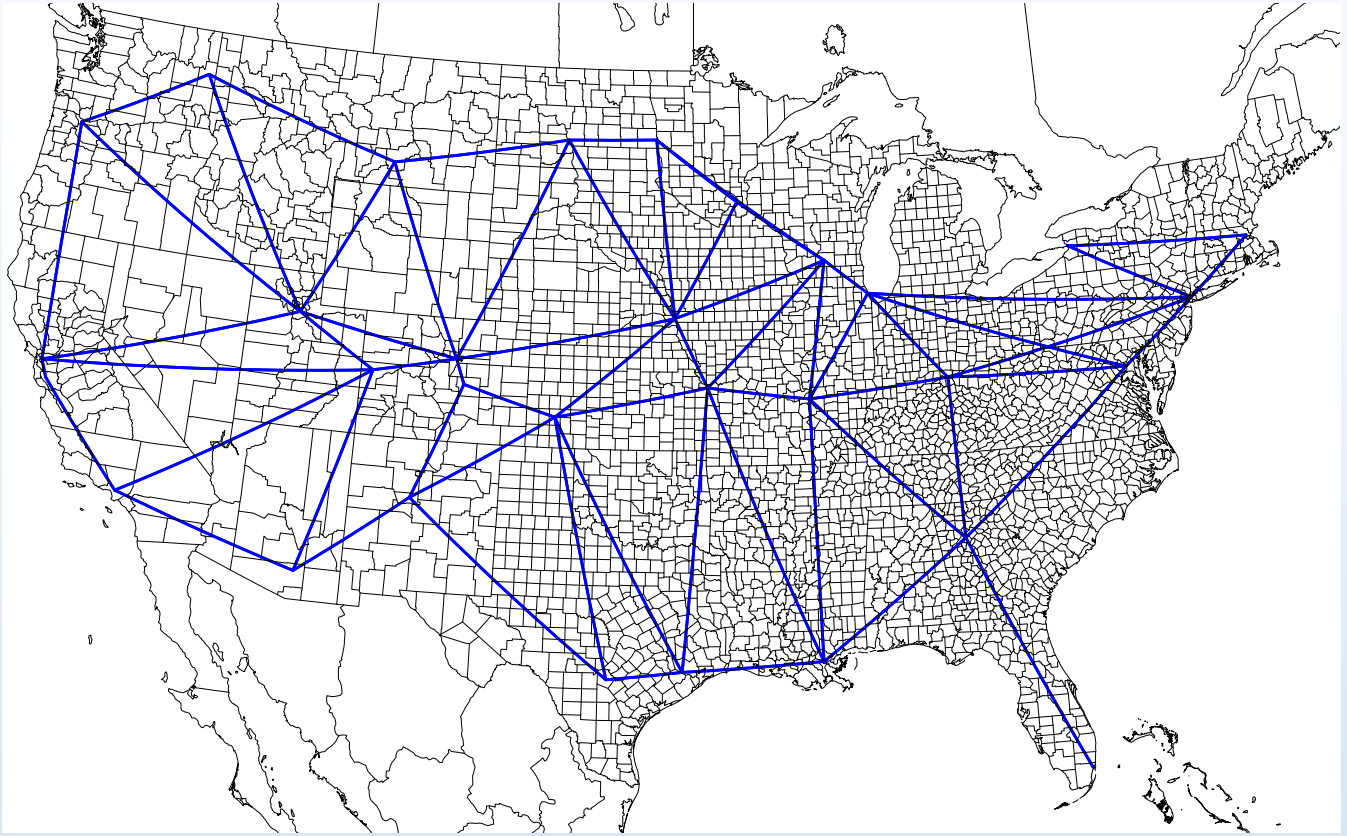
Spire Global, Inc.

Space Weather Workshop

Omni Hotel

April 27, 2016

"The study described here was accomplished while I was at NOAA."



An HVDC "superhighway for electrons"

"The US could solve the two greatest problems it faces with an underground HVDC network."

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Spire Global, Inc.

(my new employer)

Spire Plan:

- **100,000 Radio Occultations per day**
- **Each measures “Total Electron Content”**
- **~ 1 per each degree lat & lon every 12hours**

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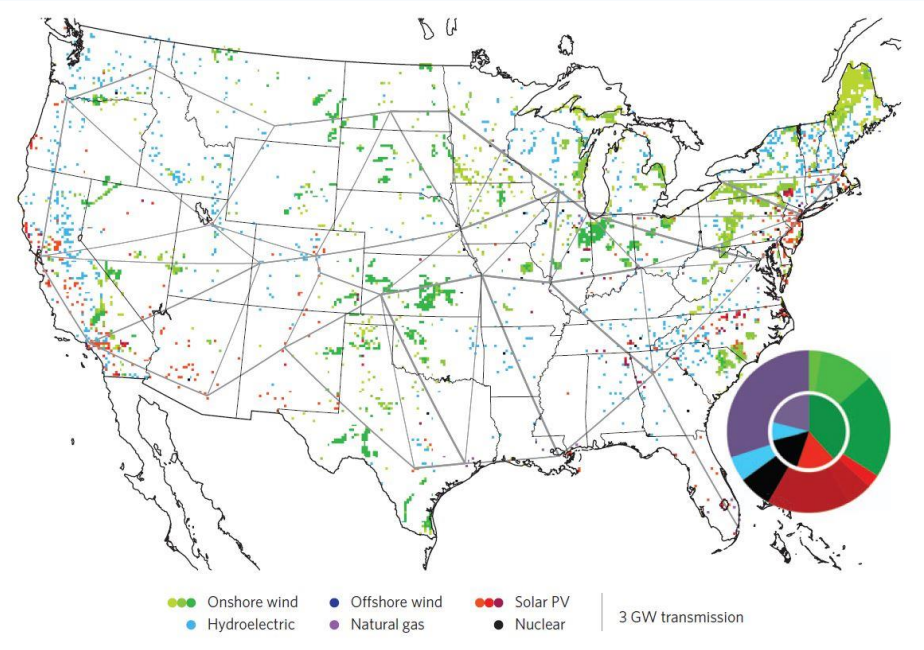
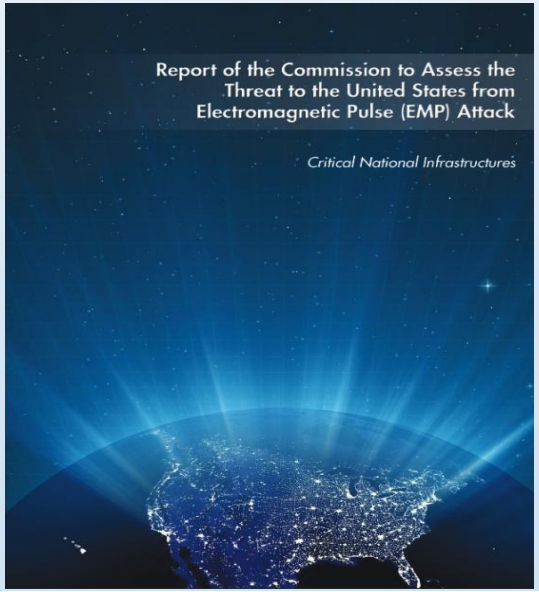
The two greatest problems the US faces:

- The threat of human induced climate change.

- The threat of massive homeland destruction from Electromagnetic Pulse or solar ejections.





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nature climate change

ARTICLES

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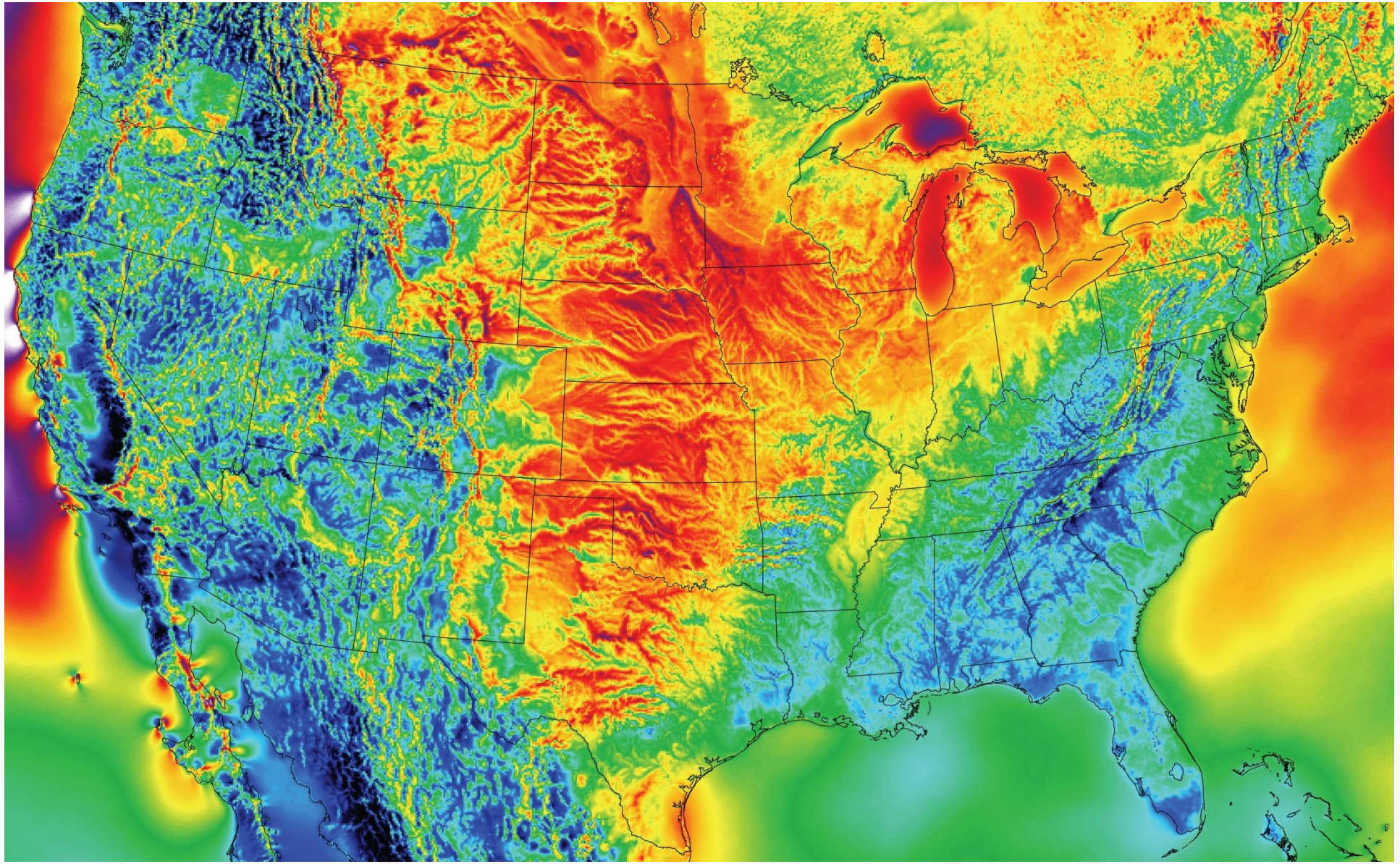
Future cost-competitive electricity systems and their impact on US CO_2 emissions

Q.1

Alexander E. MacDonald[1*†], Christopher T. M. Clack[1,2*†], Anneliese Alexander[1,2], Adam Dunbar[1], James Wilczak[1] and Yuanfu Xie[1]

Carbon dioxide emissions from electricity generation are a major cause of anthropogenic climate change. The deployment of wind and solar power reduces these emissions, but is subject to the variability of the weather. In the present study, we calculate the cost-optimized configuration of variable electrical power generators using weather data with high spatial (13-km) and temporal (60-min) resolution over the contiguous US. Our results show that when using future anticipated costs for wind and solar, carbon dioxide emissions from the US electricity sector can be reduced by up to 80% relative to 1990 levels, without an increase in the levelized cost of electricity. The reductions are possible with current technologies and without electrical storage. Wind and solar power increase their share of electricity production as the system grows to encompass large-scale weather patterns. This reduction in carbon emissions is achieved by moving away from a regionally divided electricity sector to a national system enabled by high-voltage direct-current transmission.

US Average Capacity Factor from 3 km **Weather Assimilation Model** - 2013



Purple > 50%

Red> 40%

Deep blue < 10 %

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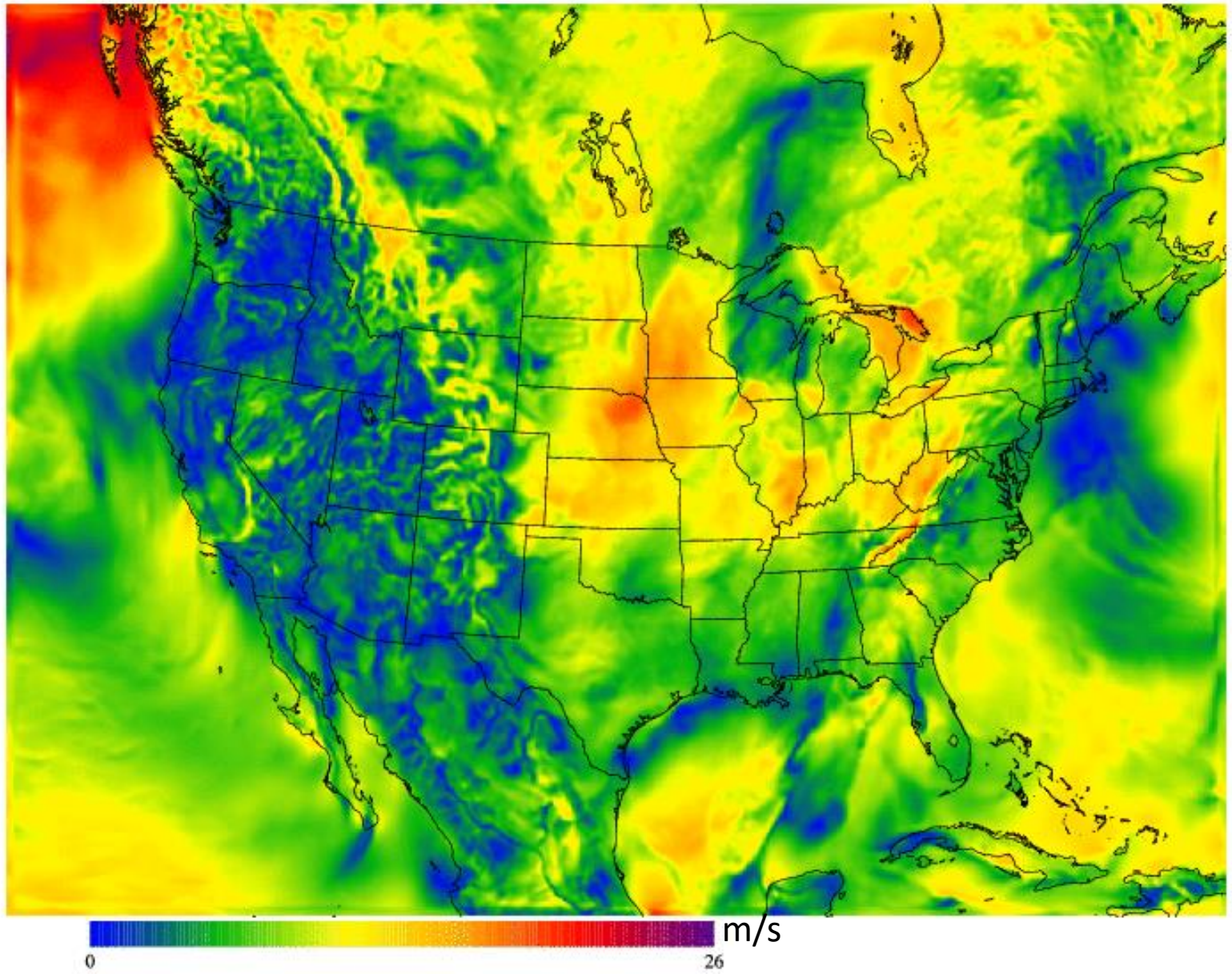
Wind Speed Video



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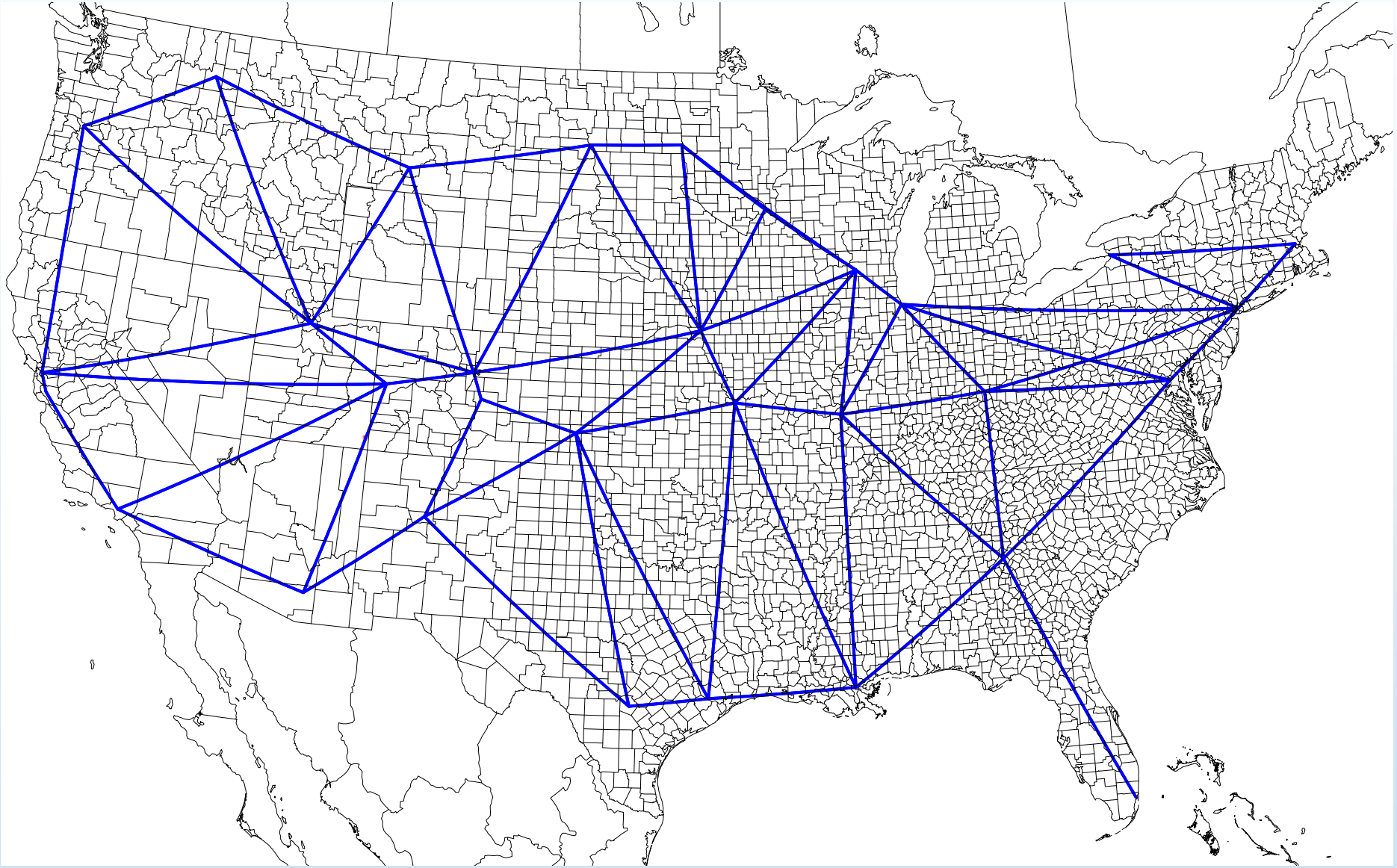
HVDC Transmission Parameterization



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National Energy System Designer

Minimize:

Subject to:

ALL OTHER EQUATIONS CONSTRAIN THE MAGNITUDE OF ANY OF THE TERMS

For details of the NEWS optimization see Clack *et al.*, IJEPES 2015.

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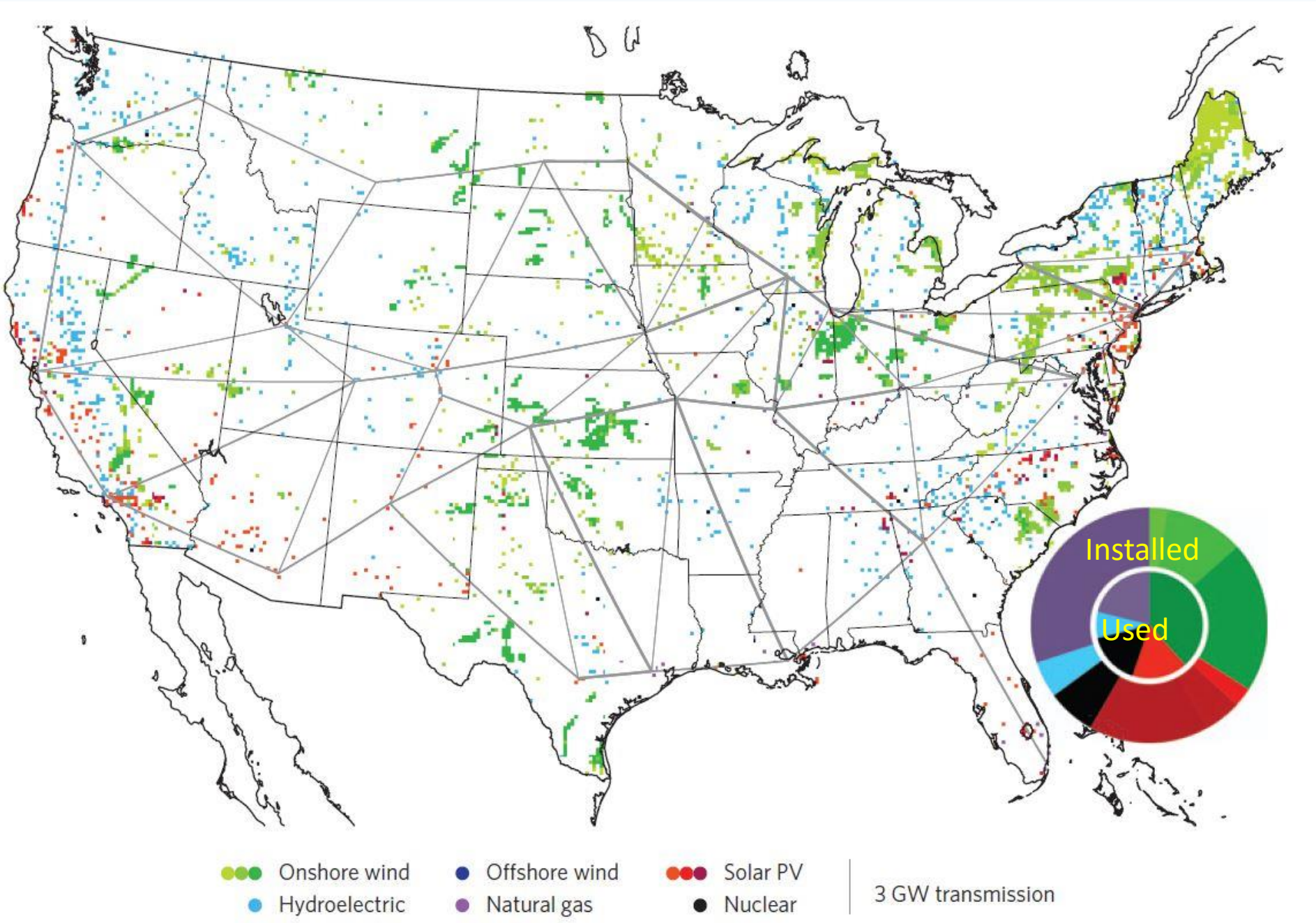
Cost optimized US Electric Power System for 2030



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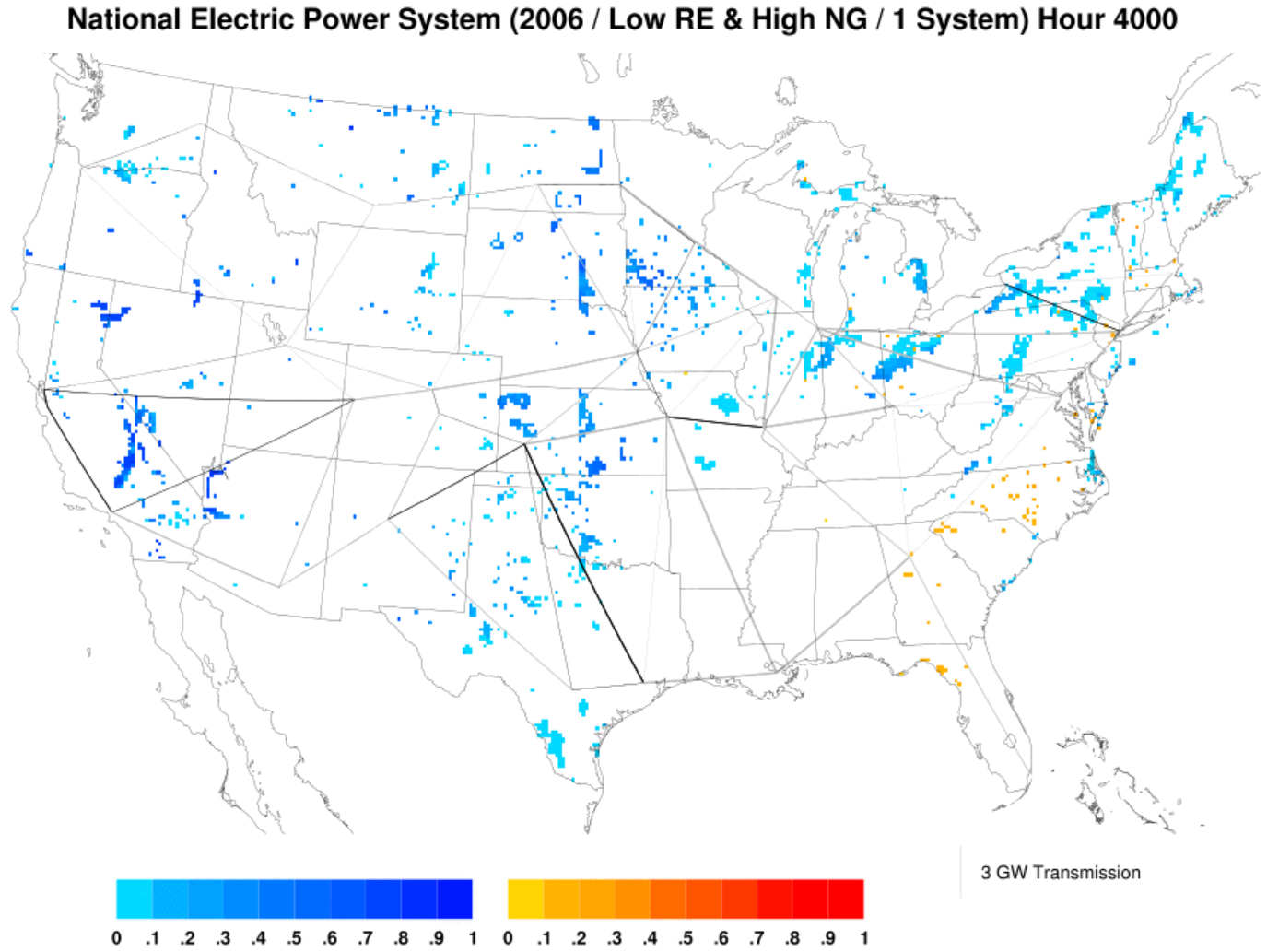
System Realtime Simulation



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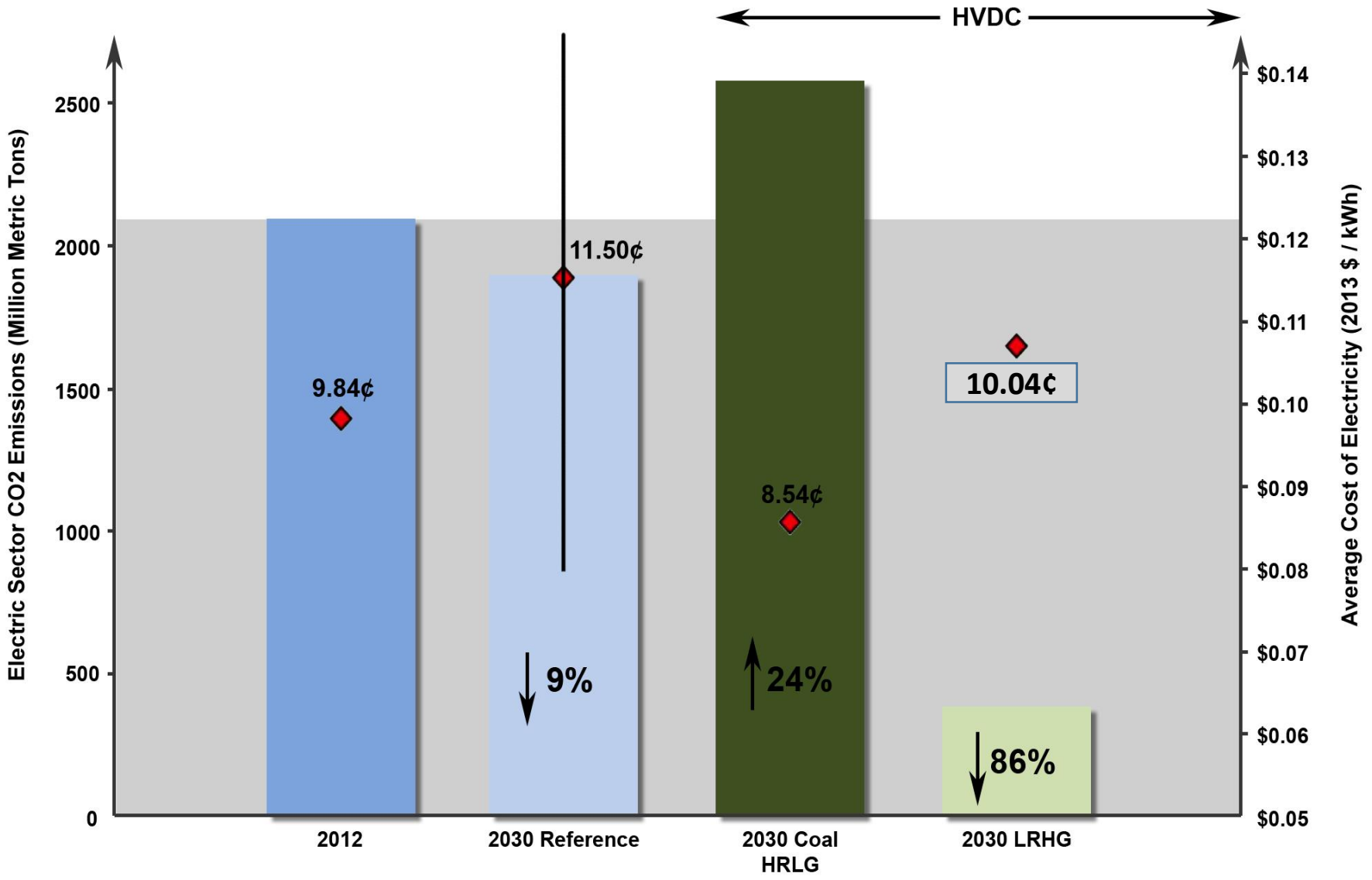
Cost and Carbon Emission Analysis



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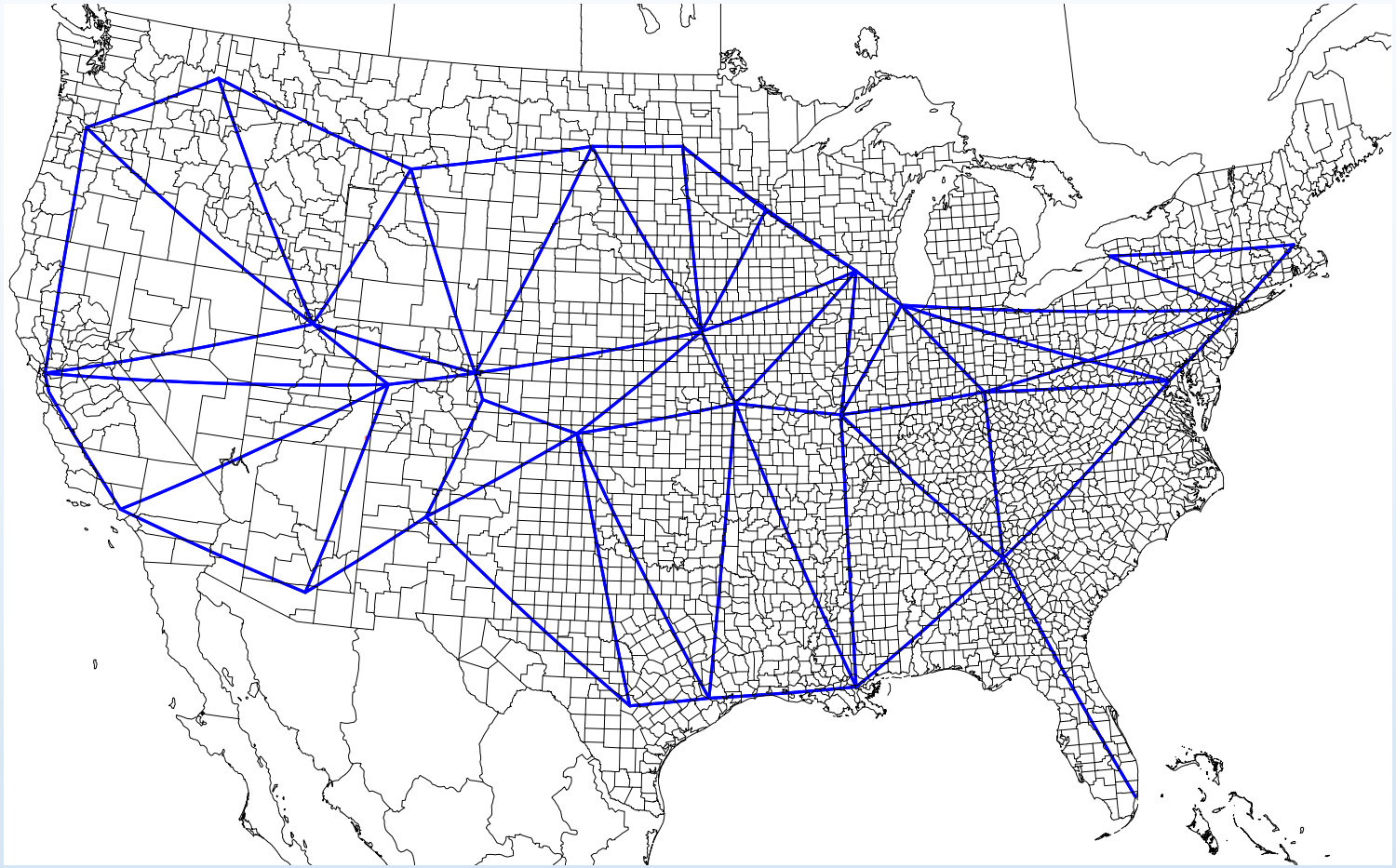
My proposal: Build an underground HVDC network by 2030.

This proposal is not part of Spire. It was developed while I was a NOAA Retiree.



Make it the backbone of a multi-point protected US electric system.

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The view from 500 km over Kansas City:

- **Direct threat of an Electromagnetic Pulse (EMP) to the entire 48 states.**
- **Today: Rogue states with missiles and specially designed EMP nuclear weapons.**
- **Tomorrow (2030s and beyond): Terrorists and small states with a grudge and a balloon.**
- **And mother nature could deliver a Carrington Event or worse.**

ABB

The new 525 kV extruded HVDC cable system

World´s most powerful extruded cable system

Anders Gustafsson, Markus Saltzer, Andreas Farkas,
Hossein Ghorbani, Tobias Quist, Marc Jeroense

High Voltage Cables
Grid Systems
Power Systems

Summary

This new 525 kV DC cable system with a power rating range of up to 2.6 GW was developed for both subsea and underground applications. The extruded HVDC cable system technology is appropriate when power needs to be efficiently delivered through populated or environmentally sensitive areas, or in coastal and open-sea applications. HVDC cable links are essential components of sustainable energy systems to connect energy markets and transmit vast amounts of electricity over very long distances, across or between continents.

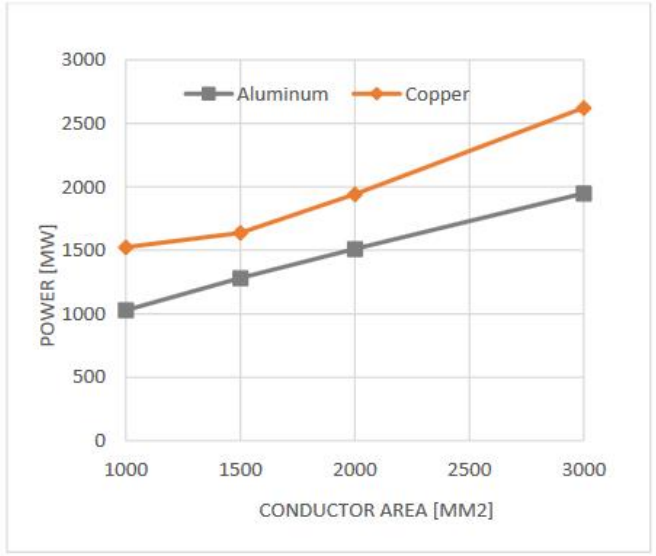

Figure 7. Transmitted power as a function of conductor area and metal for a cable pair. The Copper (3000 mm²) and Aluminium (2000 mm²) 525 kV cables are shown to the right.

- The technology needed is already commercially available.
- The design of the network would include protecting it from EMP, and building robust components of national AC distribution system.

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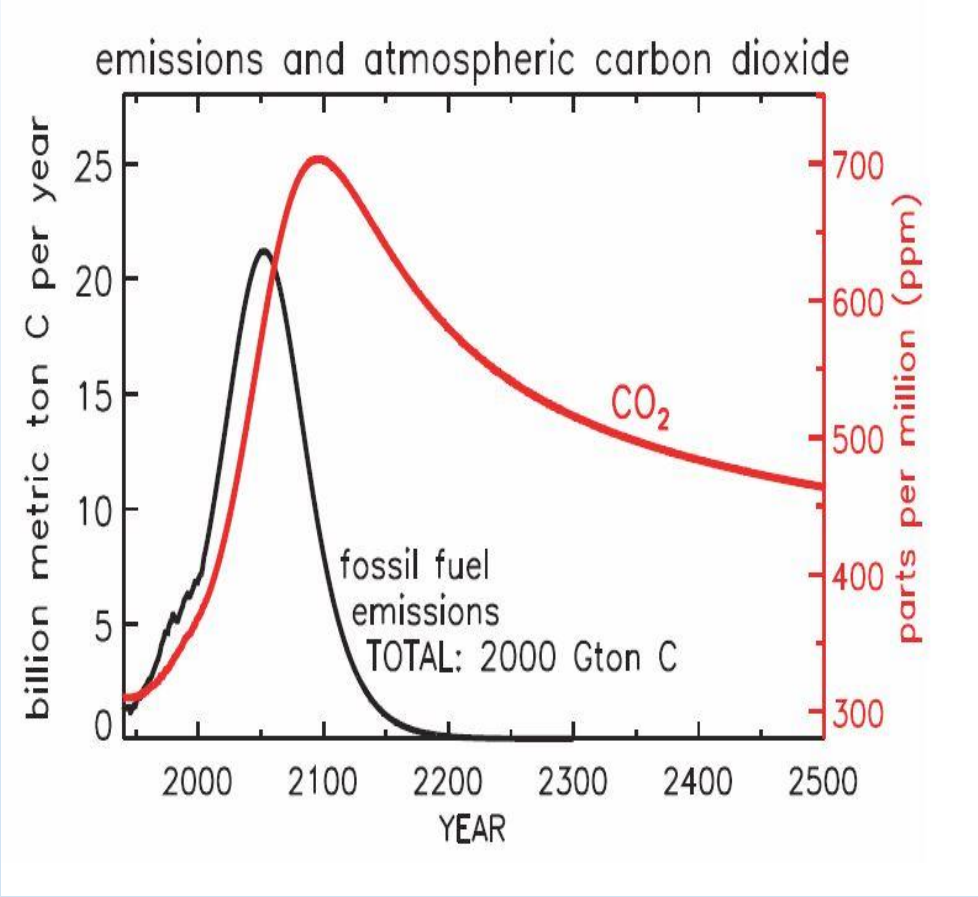
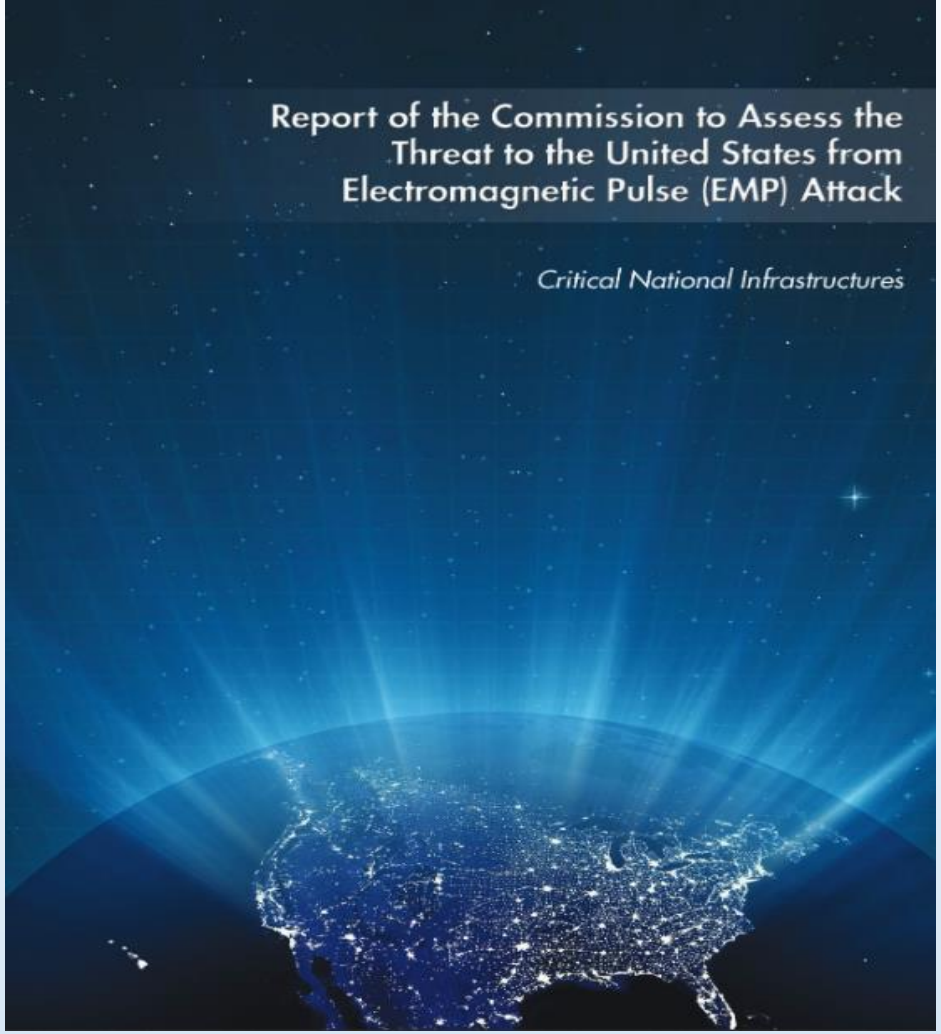
“The first duty of government is to afford protection of its citizens.”

Current policies lead to CO2 levels last seen when Greenland and Antarctica were ice free.





US civilian infrastructure is essentially unprotected from EMP and large solar events.

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QUESTIONS?

For any questions, please contact
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